Secondary interventions after elective thoracic endovascular aortic repair for degenerative aneurysms

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Objective: **We assessed the incidence and outcomes of graft-related secondary interventions (ie, open conversion or proximal or distal extensions) after elective thoracic endovascular aortic repair (TEVAR) for aneurysmal disease.**
Methods: **An institutional review of TEVAR for descending thoracic aortic aneurysms (DTAAs), between 2000 and 2011, was performed. Only elective TEVAR for DTAA using commercially available endografts was selected. Emergent cases, nonaneurysmal aortic pathology (ie, transection, pseudoaneurysm, dissection), and cases that used physician-modified devices were excluded. The incidence of unplanned graft-related secondary interventions was examined and outcomes were analyzed.**
Results: **During the study period, 83 patients underwent elective TEVAR for DTAA that met the inclusion criteria. Subsequent graft-related secondary interventions were required in eight patients (10%). The mean interval to the secondary intervention was 31.8 months. Endoleak was the most common indication. Patients who required secondary interventions were significantly younger (mean age, 58 ± 12 vs 69 ± 11 years; $P < .05$). Operative mortality (<30 day) was zero, with one aneurysm-related late death occurring at 2 years after the secondary intervention. Factors that predisposed the need for secondary interventions were fusiform morphology of the aneurysm ($P = .05$) and extent of graft coverage in the proximal landing zone <3 cm ($P < .05$). Size of the aneurysm treated and the type of device used were not significant factors leading to secondary intervention.**
Conclusions: **Intermediate and long-term results of elective TEVAR for DTAA demonstrate good durability, with acceptable rates of graft-related secondary interventions. Age, fusiform aneurysm morphology, and extent of proximal landing zones <3 cm were significant factors that led to subsequent secondary interventions. (J Vasc Surg 2013;57:1269-74.)**

Thoracic endovascular aortic repair (TEVAR) has shifted the paradigm in the treatment of thoracic aortic disease in acute and chronic settings and has led to a number of reports on satisfactory short-term and intermediate results regarding its durability.[1-6] The need for secondary interventions is an important indicator of long-term success of TEVAR. As such, data regarding the outcomes of secondary interventions are much needed to identify significant clinical risk factors and mechanisms of failure and to provide assessment on the current limitation of the evolving technology. This report analyzes the incidence and outcomes of secondary interventions after elective TEVAR with commercially available endografts for the treatment of degenerative thoracic aortic aneurysms at a high-volume center.

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METHODS

An Investigational Review Board–approved retrospective review of TEVAR for descending thoracic aneurysms (DTAA) between 2000 and 2011 was performed from a prospectively maintained database at Northwestern Memorial Hospital. Elective cases of TEVAR for DTAA using commercially available endografts were selected. Cases using surgeon-modified devices, emergent cases, and cases treating nonaneurysmal thoracic aortic pathologies were excluded. All TEVAR cases were performed from the transfemoral approach. Routine revascularization of the subclavian artery was performed when the proximal landing zone required zone II coverage for minimum 2-cm seal length.

Study definitions. Initial TEVAR success was defined as complete exclusion of the aneurysm without type I or type III endoleak verified by completion aortogram.[7] The incidence of unplanned graft-related secondary interventions, defined as any direct surgical or endovascular maneuver to prevent continued aneurysm progression (ie, open conversion, proximal and distal endograft extension, and embolization), was collected and analyzed. Treatment of nonarterial complications was not included.

Patients were under a strict follow-up protocol that required a contrast computed tomography scan at 1, 6, and 12 months after surgery and then annually thereafter. Magnetic resonance angiography was used alternatively when chronic renal insufficiency or allergy to iodinated contrast was detected.

Patient demographics and clinical comorbidities information, including history of diabetes mellitus, chronic obstructive pulmonary disease, hypertension, and coronary artery disease, was collected and assessed. Preoperative imaging information, including aneurysm morphology and size, and intraoperative data, including length of seal zones and the need for adjunct procedures (debranching, coiling, etc), was also collected and analyzed. Primary outcomes measured were death, stroke, and spinal cord ischemia. Access site and graft-related complications, including kinking, thrombosis, and infection, were collected and assessed.

Statistical analysis. Discrete data are given as counts and percentages. Comparisons of continuous data were performed by Mann Whitney *U* tests, and groups of categoric data were compared by χ^2 tests, as appropriate. Freedom from secondary open surgical conversion after TEVAR was estimated by the Kaplan-Meier method and expressed as percentages. A two-sided *P* value $<.05$ was considered statistically significant. All statistical analyses were performed with SAS 8.02 software (SAS Institute, Cary, NC).

RESULTS

During the study period, 251 TEVAR cases were performed. Of these, we identified 83 patients who underwent elective TEVAR for DTAA meeting the exclusion criteria. Mean total follow-up for the study group was 26.4 months (range, 1-123.4 months). All 83 cases were successfully performed with no immediate open conversions. There was one (1%) early (<30 days) death, two (2%) strokes, and one (1%) incidence of spinal cord ischemia. There were eight operative complications (10%), including four access site complications (5%), one distal embolism (1%), and three wound infections (4%) that were related to open femoral cutdowns.

Secondary interventions were acquired at a continuous rate throughout the follow-up period. Eight patients (10%) who underwent elective TEVAR for DTAA required secondary interventions. The mean interval to secondary intervention was 31.8 months after the initial procedure (range, 0.5-71.2 months). Two patients in the secondary intervention group required open conversion, five required secondary TEVAR (three proximal extension, one distal extension, and one relining), and one required endovascular coiling only for a type II endoleak. The cumulative rates of freedom from intervention were 96% at 2 years and 85% at 5 years (Fig 1).

Five different commercially available devices were used in the study: the TX2 endograft (Cook Medical, Bloomington, Ind), the TAG and the newer-generation C-TAG devices (Gore Medical, Flagstaff, Ariz), and the Talent and the newer-generation Valiant devices (Medtronic, Minneapolis, Minn). The types of stent grafts and the frequency of their use are summarized in Table I. For all devices, the size (diameter) of the stent graft deployed was calculated from the largest diameter of the proximal or distal neck with addition of an oversizing factor of 20%. A proximal and distal landing zone requirement of 2 cm per universal device instructions for use was adhered to in each of the cases. When a comparison of device type used was made between the cohort requiring secondary intervention and the no reintervention group, the type of device was not a significant factor leading to secondary interventions ($P = .54$).

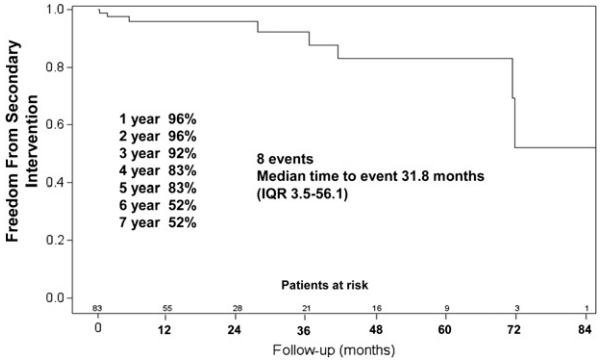

Fig 1. Cumulative durability of thoracic endovascular aortic repair (TEVAR) is shown by Kaplan-Meier curves of secondary intervention-free survival. *IQR,* Interquartile range.

Endoleak was the most common indication leading to secondary interventions. The type of endoleak and subsequent method of treatment is summarized in Table II. Five patients underwent secondary intervention for a type I endoleak: four for type IA (Fig 2) and one for type IB. One patient underwent secondary intervention for a type II endoleak and one for a type III endoleak. One patient had no detectable endoleak, but aneurysmal progression continued on surveillance that required reintervention. To treat these graft-related failures, two patients required conversion to an open aortic repair (both arch replacements), and five required secondary TEVAR, comprising three proximal extensions, one distal extension, and one relining for type III endoleak. In conjunction to the TEVAR, two patients required arch debranching (one carotid-to-carotid bypass and one carotid-to-subclavian bypass). One patient required just an endovascular coiling of a type II endoleak.

Patient demographics and clinical comorbidities were compared between the secondary intervention cohort and the no reintervention cohort (Table III). Patients who required secondary interventions were significantly younger than the patients who required no reinterventions (mean age, 58 ± 12 vs 69 ± 11 years; $P < .05$). Patient gender and medical comorbidities, including coronary artery disease, chronic obstructive pulmonary disease, diabetes mellitus, and hypertension, were not significantly different between the two groups. Any history of aortic surgeries (ie, prior arch reconstruction, abdominal aortic repairs) was also examined. Patients who underwent secondary interventions did not have a higher rate of prior aortic operations compared with the no reintervention group ($P = .7$).

Table I. Types of endografts used

Device type	*Secondary intervention*[a] *(n = 8), No. (%)*	*No reintervention*[a] *(n = 75), No. (%)*
Cook TX2[b]	0 (0.0)	4 (5)
Gore C-TAG[c]	0 (0.0)	4 (5)
Gore TAG[c]	5 (60)	52 (69)
Medtronic Talent[d]	3 (40)	12 (16)
Medtronic Valiant[d]	0 (0.0)	3 (4)

[a]The *P* values = .54.
[b]Cook Medical, Bloomington, Ind.
[c]W.L. Gore & Associates, Flagstaff, Ariz.
[d]Medtronic, Minneapolis, Minn.

Table II. Indication for secondary intervention and types of subsequent management

Indication	*Secondary intervention (n = 8), No.*
Endoleak	
Type IA	4
Type IB	1
Type II	1
Type III	1
Aneurysmal progression, no detectable endoleak	1
Required treatment	
Endovascular	6
Open (arch replacement)	2
Secondary TEVAR	5
Proximal extension	3
Arch debranching	2
Distal extension	1
Relining	1
Coiling only	1

TEVAR, Thoracic endovascular aortic repair.

Aneurysm size and morphology were also examined and compared between the two groups. The mean diameter of the aneurysm treated between the patients who underwent secondary intervention compared with patients with no reinterventions, 6.2 ± 0.7 vs 6 ± 1.2 cm, respectively, was not significantly different ($P = .57$). All patients who underwent secondary interventions were initially treated for fusiform aneurysms. Patients who underwent TEVAR for the treatment of saccular aneurysms did not require secondary interventions in this study. This was significantly different ($P = .05$).

We examined whether the length of proximal coverage along with the need for coverage of the subclavian artery at the time of initial TEVAR were significant determinants for subsequent reintervention. Any graft needing zone II landing for required 2-cm coverage had left subclavian revascularization with subsequent ligation or embolization. Five of the eight patients needing secondary interventions required debranching of the left subclavian artery and coiling or carotid-subclavian transposition for extension of the proximal landing zone during the initial TEVAR. Twenty-five patients (33%) in the no reintervention group required coverage of the left subclavian artery. Although the frequency of left subclavian coverage was lower in the no reintervention group, the difference was not statistically significant ($P = .13$). The proximal seal length was measured and compared between the two groups. The mean length of the proximal landing zone was 2.3 ± 1.2 cm in the secondary intervention group vs 3.3 ± 1.1 cm in the no reintervention group. This was significantly different ($P = .03$).

The complication rates in patients who underwent secondary interventions were compared with the patients requiring no reinterventions. The results are summarized in Table IV. In the secondary intervention group, clinically relevant perioperative (<30 days) events occurred in three patients, with one stroke and two access site complications. Operative mortality (<30 day) was zero as was the incidence of spinal cord injury. All complications occurred after secondary TEVARs. No unexpected events occurred in the two patients who underwent open conversion. One aneurysm-related late death occurred at 1.5 years in a patient who underwent open aortic arch replacement. The patient developed an irrecoverable infection of the prosthetic graft and died after comfort measures were initiated.

Early perioperative events occurred in 11 patients in the no reintervention group. The most common operative complication was access-related in four patients (5%). There was one (1%) early death, one (1%) stroke, and one (1%) incidence of spinal cord injury. There was one procedure-related distal embolism and resultant limb loss. Surgical site infection from groin cutdown for femoral access occurred in three patients (4%) in this cohort. Three patients (4%) in the no reintervention cohort died late (>90 days) after TEVAR from suspected aneurysm rupture. The cumulative rates of early and late operative complications after secondary interventions were not statistically different compared with patients who did not require reintervention ($P = .999$).

DISCUSSION

The need for secondary interventions is an important indicator of the durability of endovascular aortic repair. Existing publications that have reported outcomes after TEVAR largely consist of mixed elective and emergency cases for varying thoracic aortic disease, including aortic dissections and penetrating aortic ulcers.[8-12] Our assessment of TEVAR outcomes was restricted to reviewing data from those patients who were electively treated for degenerative thoracic aneurysms using off-the-shelf devices. We believe that limiting the analysis to the particular aortic pathology that TEVAR was originally designed to treat (degenerative aneurysms) that are within device instructions for use, allows for a more accurate evaluation of the durability and limitations of the technology. Further restricting the analysis to commercially available endografts enhances the clarity of this report.

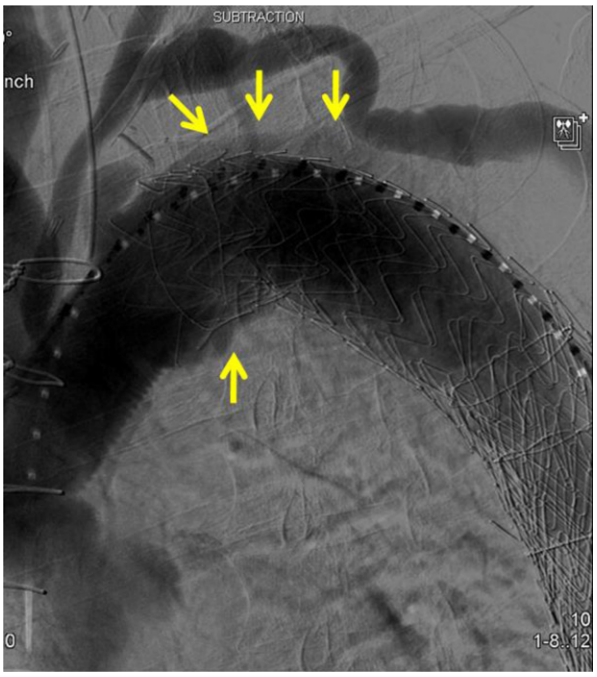

Fig 2. An intraoperative arch aortogram demonstrates a type IA endoleak (*arrows*) after thoracic endovascular aortic repair (TEVAR).

Table III. Demographic, clinical, and morphologic characteristics of patients requiring secondary interventions and no reinterventions

Variable [a]	*Secondary intervention (n = 8)*	*No reintervention (n = 75)*	P
Characteristics			
Age, years	58 ± 12	69 ± 11	.0069
Male sex	3 (38)	45 (60)	.2725
Coronary artery disease	6 (75)	66 (88)	.8024
COPD	3 (38)	37 (49)	.7421
Diabetes mellitus	2 (25)	33 (44)	.1572
Hypertension	8 (100)	62 (83)	.6723
History of prior aortic surgery	3 (38)	23 (31)	.7010
Aneurysm size, cm	6.2 ± 0.7	6 ± 1.2)	.5702
Morphology			.0522
Fusiform	8 (100.0)	49 (65)	
Saccular	0 (0.0)	26 (35)	
Proximal involves coverage of the left subclavian artery	5 (63)	25 (33)	.1307
Proximal landing zone, cm	2.3 ± 1.2	3.3 ± 1.1	.0320

COPD, Chronic obstructive pulmonary disease.
[a]Continuous data are shown as mean ± standard deviation and categoric data as number (%).

The European Collaborators on Stent-Graft Techniques for Aortic Aneurysm Repair (EUROSTAR) registry collaborators have the largest study to date, which reviewed secondary interventions after elective TEVAR cases. They reported a 2-year freedom from intervention rate of 83% in 213 elective TEVAR cases studied.[13]

Table IV. Outcomes of secondary intervention vs no reintervention

Outcomes	*Secondary intervention (n = 8), No. (%)*	*No reintervention (n = 75), No. (%)*	P
Early (<30 days) complications	3 (38)	11 (15)	.3623
Death	0 (0)	1 (1)	.9999
Stroke	1 (13)	1 (1)	.5777
Spinal cord injury	0 (0)	1 (1)	.9999
Access site complications	2 (25)	4 (5)	.4844
Distal embolism	0 (0)	1 (1)	.9999
Infection	0 (0)	3 (4)	.7536
Late (>90 days) aneurysm-related death	1 (13)	3 (4)	.5023

In our series of 83 elective patients, we report a 2-year cumulative durability of 96% and a 5-year durability of 83% for elective TEVAR, with a mean time to intervention of 32 months (Fig 1). The absolute secondary intervention rate of 10% is also lower than the 12% reported by the registry[13] but approaches the rates reported with current-generation endografts in the treatment of abdominal aortic aneurysms (EVAR).[14,15] As reported in other studies, the type of endograft used was not a significant determinant of TEVAR success[13,16,17] and the performance of all currently available off-the-shelf devices can be concluded to be equal. The improved rates of secondary interventions reported in our series may be the result of institutional uniformity in the approach to TEVAR cases along with selection bias for cases that have strictly adhered to anatomic standards required by current commercial endografts.

As with other reports, endoleak was the most common etiology leading to secondary interventions,[8,13,17,18] and proximal type IA endoleak was the most prevalent type (Table II). Interestingly, one patient had progression of the aneurysm sac without a detectable endoleak. Most endoleaks were managed with endovascular techniques, with a 25% rate of open conversion in our series. Of those that required secondary endovascular interventions, arch debranching was required in one-third of the patients. On the basis of our findings, most late TEVAR failures can be managed with endovascular means. The need for open debranching or full open conversion rate, however, is not insignificant.

Of the patient clinical and demographic risk factors assessed, younger age was correlated significantly with the need for secondary intervention (Table III). There was no difference in the prevalence of medical comorbidities in the patients who underwent secondary interventions. Younger age as a determinant of TEVAR failure contradicts the findings of other reports where older age was correlative. A recent study by Alsac et al[18] found that age >80

years was a determinant of significant endoleaks requiring intervention. Careful analysis of the study revealed that all of the older patients who developed significant endoleaks in that study had fusiform aneurysm morphology, which may be the more important determinant of TEVAR failure. Fusiform morphology, compared with saccular morphology where aortic deterioration is localized, is indicative of a progressive ectatic process that allows diffuse deterioration of the aortic wall. The eight patients who underwent secondary intervention in our study also had fusiform aneurysms, which was significant (Table III). What we are observing in this study may be that younger age is an indicator for risk accumulation; the younger the patient, the greater the cumulative risk of progressive aortic ectasia, subsequent aneurysm progression, and hence, TEVAR failure. Young age and fusiform morphology, where a global degenerative process exists, become synergistic determinants of later secondary intervention.

Further analysis of the morphologic characteristics of aneurysms treated in our study showed that aneurysm size and a proximal neck requiring debranching for adequate coverage (involves coverage of the left subclavian) were not significant factors leading to secondary intervention (Table III). The most significant anatomic determinant for TEVAR success appeared to be the length of the proximal landing zone <3 cm. The mean length of proximal endograft seal was 2.3 cm, greater than the indicated 2-cm seal zone that is universal among the commercially available endografts used.[1,9,19-22] As previously reported,[23] to obtain the required 2-cm proximal neck, debranching of the left subclavian artery and subsequent coverage of the ostium was often undertaken in our cases (30 of 83 cases, 36%). In comparison, the mean length of proximal seal in the no reintervention group was 3.3 cm in our study. A number of other studies have demonstrated that the current IFU of a 2-cm graft-to-aorta seal zone may not be enough[4,16,18] and should be extended to 3 cm. Unfortunately, we did not have complete measurements of the proximal diameter at the seal zone for analysis and admit that this is a weakness of this study.

The initial technical success of TEVAR was 100% in our study. Patients who received a secondary intervention did not have increased morbidity or mortality compared with patients who did not undergo a reintervention. The comparative complication rates were not significantly different between the two groups, and the assessment may be limited by the overall small numbers in the cohort. Access site complications were the most prevalent in the secondary intervention group and the no reintervention group (Table IV).

CONCLUSIONS

Elective endovascular repair of degenerative thoracic aneurysms using commercially available devices has acceptable durability and outcomes approaching that of EVAR. All available off-the-shelf grafts seem to perform equally. We found that most secondary interventions can be managed with endovascular techniques and have acceptable rates of operative complications and mortality. The need for open conversion and arch debranching, however, is not insignificant. The risk of secondary intervention is greatest in young patients with fusiform aneurysms, who require regular surveillance imaging and follow-up. The length of proximal endograft seal is critical, and the current standard of 2-cm coverage may not be adequate, as implied by the data in this study as well as others. We propose the requirement of a 3-cm seal for durable outcomes after TEVAR.

AUTHOR CONTRIBUTIONS

Conception and design: CL, ME
Analysis and interpretation: CL, ME
Data collection: CL
Writing the article: CL
Critical revision of the article: CL, HR, MK, SM, ME
Final approval of the article: CL, HR, MK, SM, ME
Statistical analysis: CL
Obtained funding: ME
Overall responsibility: ME

REFERENCES

1. Greenberg RK, O'Neill S, Walker E, Haddad F, Lyden SP, Svensson LG, et al. Endovascular repair of thoracic aortic lesions with the Zenith TX1 and TX2 thoracic grafts: intermediate-term results. J Vasc Surg 2005;41:589-96.
2. Neuhauser B, Perkmann R, Greiner A, Steingruber I, Tauscher T, Jaschke W, et al. Mid-term results after endovascular repair of the atherosclerotic descending thoracic aortic aneurysm. Eur J Vasc Endovasc Surg 2004;28:146-53.
3. Makaroun MS, Dillavou ED, Wheatley GH, Cambria RP. Five-year results of endovascular treatment with the Gore TAG device compared with open repair of thoracic aortic aneurysms. J Vasc Surg 2008;47:912-8.
4. Czerny M, Roedler S, Fakhimi S, Sodeck G, Funovics M, Dumfarth J, et al. Midterm results of thoracic endovascular aortic repair in patients with aneurysms involving the descending aorta originating from chronic type B dissections. Ann Thorac Surg 2010;90:90-4.
5. Jonker FH, Verhagen HJ, Lin PH, Heijmen RH, Trimarchi S, Lee WA, et al. Outcomes of endovascular repair of ruptured descending thoracic aortic aneurysms. Circulation 2010;121:2718-23.
6. Garcia-Toca M, Eskandari MK. Regulatory TEVAR clinical trials. J Vasc Surg 2010;52(4 Suppl):22S-5S.
7. Fillinger MF, Greenberg RK, Mckinsey JF, Chaikof EL. Reporting standards for thoracic endovascular aortic repair (TEVAR). J Vasc Surg 2010;52:1022-33.
8. Lin PH, El Sayed HF, Kougias P, Zhou W, LeMaire SA, Coselli JS. Endovascular repair of thoracic aortic disease: overview of current devices and clinical results. Vascular 2007;15:179-90.
9. Ting AC, Cheng SW, Ho P, Chan YC, Poon JT, Cheung GC. Endovascular repair of thoracic aortic pathologies—early and midterm results. Asian J Surg 2009;32:39-46.
10. Desai ND, Pochettino A, Szeto WY, Moser GW, Moeller PJ, Sodhi N, et al. Thoracic endovascular aortic repair: evolution of therapy, patterns of use, and results in a 10-year experience. J Thorac Cardiovasc Surg 2011;142:587-94.
11. Gopaldas RR, Huh J, Dao TK, LeMaire SA, Chu D, Bakaeen FG, et al. Superior nationwide outcomes of endovascular versus open repair for isolated descending thoracic aortic aneurysm in 11,669 patients. J Thorac Cardiovasc Surg 2010;140:1001-10.
12. Brown KE, Eskandari MK, Matsumura JS, Rodriguez H, Morasch MD. Short and midterm results with minimally invasive

endovascular repair of acute and chronic thoracic aortic pathology. J Vasc Surg 2008;47:714-22; discussion: 22-3.
13. Leurs LJ, Harris PL, Buth J. Secondary interventions after elective endovascular repair of degenerative thoracic aortic aneurysms: results of the European collaborators registry (EUROSTAR). J Vasc Interv Radiol 2007;18:491-5.
14. Lalka S, Dalsing M, Cikrit D, Sawchuk A, Shafique S, Nachreiner R, et al. Secondary interventions after endovascular abdominal aortic aneurysm repair. Am J Surg 2005;190:787-94.
15. Laheij RJ, Buth J, Harris PL, Moll FL, Stelter WJ, Verhoeven EL. Need for secondary interventions after endovascular repair of abdominal aortic aneurysms. Intermediate-term follow-up results of a European collaborative registry (EUROSTAR). Br J Surg 2000;87: 1666-73.
16. Czerny M, Funovics M, Sodeck G, Dumfarth J, Schoder M, Juraszek A, et al. Long-term results of thoracic endovascular aortic repair in atherosclerotic aneurysms involving the descending aorta. J Thorac Cardiovasc Surg 2010;140(6 Suppl):S179-84; discussion: S85-90.
17. Morales JP, Greenberg RK, Lu Q, Cury M, Hernandez AV, Mohabbat W, et al. Endoleaks following endovascular repair of thoracic aortic aneurysm: etiology and outcomes. J Endovasc Ther 2008;15: 631-8.
18. Alsac JM, Khantalin I, Julia P, Achouh P, Farahmand P, Capdevila C, et al. The significance of endoleaks in thoracic endovascular aneurysm repair. Ann Vasc Surg 2011;25:345-51.
19. Melissano G, Kahlberg A, Bertoglio L, Chiesa R. Endovascular exclusion of thoracic aortic aneurysms with the 1- and 2-component Zenith TX2 TAA endovascular grafts: analysis of 2-year data from the TX2 pivotal trial. J Endovasc Ther 2011;18:338-49.
20. Kasirajan K. New C-TAG device and overcome of compression events. J Cardiovasc Surg (Torino) 2012;53:169-72.
21. Fairman RM, Criado F, Farber M, Kwolek C, Mehta M, White R, et al. Pivotal results of the Medtronic Vascular Talent Thoracic Stent Graft System: the VALOR trial. J Vasc Surg 2008;48:546-54.
22. Fairman RM, Tuchek JM, Lee WA, Kasirajan K, White R, Mehta M, et al. Pivotal results for the Medtronic Valiant Thoracic Stent Graft System in the VALOR II trial. J Vasc Surg 2012;56:1222-31.e1.
23. Peterson BG, Eskandari MK, Gleason TG, Morasch MD. Utility of left subclavian artery revascularization in association with endoluminal repair of acute and chronic thoracic aortic pathology. J Vasc Surg 2006;43:433-9.

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